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(71) Applicant *(for all designated States except US)*: MYDATA AUTOMATION AB [SE/SE]; Karlsbodavägen 39, S-161 70 BROMMA (SE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: JACOBSSON, Nils [SE/SE]; Fallskärmsvägen 31, S-175 63 Järfälla (SE).

(74) Agents: LINDÉN, Stefan et al.; Bergenstråhle & Lindvall AB, P.O. Box 17704, S-118 93 Stockholm (SE).

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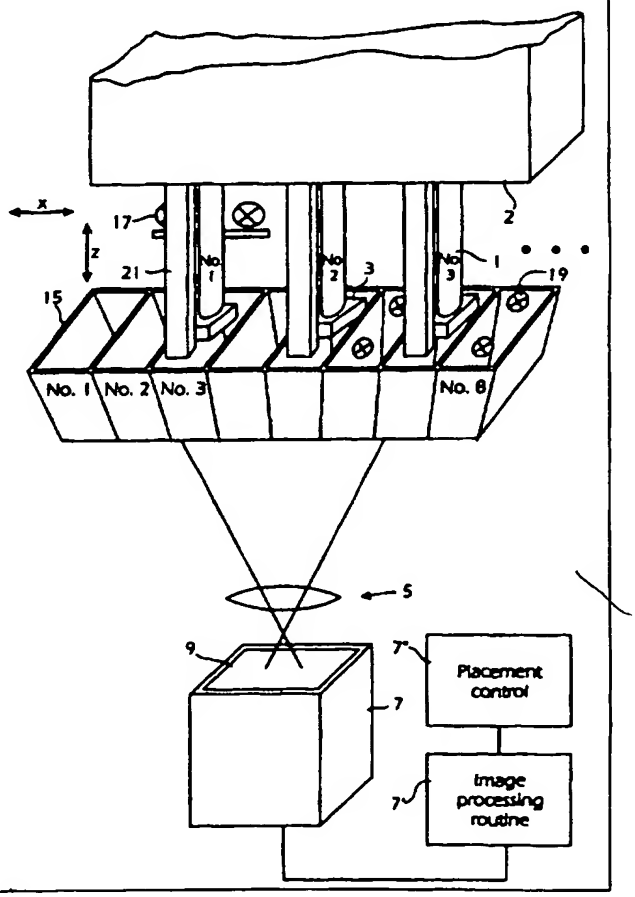
(57) Abstract

A pickup head (2) for an automatic component assembly machine comprises several pipettes (1) placed next to each other for retaining components (3) at the sucking nozzles of the pipettes. An image of the component is captured by means of a video camera (7) and a lens system (5) to be used in an automatic evaluation (7') of the positions of the components on the pipettes (1). This image is composed by superposing successive images, which are captured of only one component (3) at a time. With a suitable movement of the pickup head (2) between the capturing of the successive images the reproductions of the individual components can be packed closely in the composed image. This results in that the lens system (5) can be adjusted for a larger magnification than if only one image had been captured of all the components (3) at the same time. Thereby a more accurate determination of the positions of the components can be achieved in the evaluation.



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COMPACT REPRODUCTION OF COMPONENTS

TECHNICAL FIELD

The present invention relates to reproduction of several components, in particular components retained by a row of pickup devices in a component assembly machine, such as an assembly machine for the automatic mounting of electronic and similar components.

BACKGROUND

Automatic assembly machines for electronic components conventionally have a pickup head, which picks electronic components from different magazines and places them on accurately determined locations on a circuit board. The pickup head can have a number of individual pickup devices or sucking pipettes whereby in a pickup movement of the pickup head several components are picked at the same time, so that after the pickup operation the pickup head carries several components. For the accurate positioning of the components, automatic image processing can be used and then an image of all the simultaneously retained components is captured, when the pickup head and all its separate pickup devices, by which the components are retained, adopt accurately predetermined reference positions. The sucking nozzles of the pickup devices are then placed in a row and thus the components are also generally retained in positions along a line. During normal image capturing, image fields or fields of view are used, which are generally rectangular and have dimensions, which do not differ too much from a quadratic shape, for instance having a ratio of normally 4:3 of the long and short sides of the image field at most. When components are reproduced by means of a device having such an image field, only the central horizontal part of the image, parallel to the long sides of the image field, can be used in the image processing, what gives a poor utilization of the captured image. Thus, when using an image processing device having discrete light sensitive elements such a CCD-camera, only a few pixel points of the captured image will be used during the image processing, most of the pixel points being totally irrelevant for the information to be extracted.

Conventional methods for capturing an image of electronic components before automatic or electronic image processing can comprise one of :

- 1. Capturing one image of the component at each time.
- 2. Capturing several images of one component successively.
- 3. Capturing an image of several components at one time, so that the image shows all the components.

Superposing different pictures of a component is described in the Japanese patent applications JP-A 5-37195, JP-A 2-280400 and JP-A 3-208399.

SUMMARY

It is an object of the invention to provide a method and a device for capturing an image of several components placed in a row having a good resolution of each reproduced component.

It is a further object of the invention to provide an automatic component assembly

machine in which an accurate reproduction is made of the components, the reproduction having a good resolution of several simultaneously retained components.

These objects are achieved by the invention, the characteristics of which are set out in and the scope of which is defined by the appended claims.

A composite image is produced through a successive exposure of the components, whereby the reproductions of the individual components can be closely or densely packed in the final image.

Thus a pickup head for an automatic component assembly machine comprises several pickup devices or tools such as pipettes placed next to each other for retaining components at their bottom surfaces. An image of the components is captured by means of a reproduction system, such as a video camera and a lens arrangement, in order to be used in an automatic evaluation of the position of the components at the tools. This image is composed by superposing successive images, which are captured of only one component at each time. By a suitable movement of the pickup head between the capture of the successive images the reproductions of the individual components can be closely packed in the composite image. This results in that the lens arrangement can be set for a greater magnification than if only one image simultaneously had been captured of all the components. Thereby a more accurate determination of the positions of the components can be obtained in the evaluation.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of a non-limiting embodiment and with reference to the accompanying drawings, in which:

- Fig. 1 is a schematic perspective view of parts of a pickup head for an automatic component assembly machine having schematically shown illumination means and optical means for capturing an image of retained components,
- Fig. 2 is an image of retained components captured by means of conventional optical devices,
- Fig. 3 is an image of retained components captured so that the individual pictures of the components are packed,
- Fig. 4 is an image captured as in Fig. 3 but having an increased magnification and
- Fig. 5 is a perspective view of a component assembly device.

DETAILED DESCRIPTION

In the upper part of Fig. 1, the lower portions of a pickup tool and pipettes 1 are shown belonging to a pickup and placement head or a component fetching head, indicated at 2, of an automatic assembly machine for electronic components. The pickup head 2 is placed on an x-head, which is movable in a horizontal direction, the x-direction. The pipettes 1 are arranged in a row, i.e. parallel to each other in the same vertical plane, which is advantageously parallel to the x-direction, and they are placed at equally spaced distances from each other and retain components 3 at their lower ends, which are equipped with sucking nozzles. The components 3 are picked up through amongst others a movement of the pickup head 2 in the

x-direction and then, when the head 2 having the pipettes 1 is moved to a location, where the components are to be placed, it passes over a location, where an image can be captured of the components 3 from underneath by means of a fixedly mounted image capturing system. It comprises a lens arrangement 5 and a video camera 7 having a light sensitive surface 9 and is placed on a suitable location under the path of movement of the components 3 in order to capture an image thereof. The image captured by the video camera 7 is communicated to an image evaluation device 7', where a determination of the positions of the components is made, the result of the determination being then transferred to a control unit 7" arranged to control the movement of the x-wagon, the pickup head 2 and the movement of the individual pipettes 3 in relation thereto.

The image of all the components obtained hereby is schematically shown in Fig. 2 comprising a rectangular image field 11 and individual pictures 13 of the components 3 thereon. The individual pictures 13 have then basically the same outer shape or profile as the components, typically a rectangular shape, and are placed in a row along an approximately straight line, normally in the centre of the image field 11 in parallel to its one of its sides, typically the long side. Due to the row-wise arrangement of the components 3 and hereby of their reproductions 13, normally only the central part of the image field 11 is used for the reproduction, at least if the components 3 are not too elongated, and thereby information only needs to be collected from this area during an automatic image processing of the signals from the light sensitive elements on the surface 9. The information from other parts of the image field 11 cannot be used.

In order to pack the reproductions of the individual components 3 more closely in the image field 11, so that a greater magnification can be chosen, pictures can instead be successively captured of each individual component retained by a pickup tool 1, and the whole head 2 can be moved between each capturing of an image, so that a component, for which an image is directly captured after an image is captured for another component, is placed in the camera field closer to the position of the previous component. The latter of these images is superposed on previously captured images, whereby a resulting image according to Fig. 3 can be obtained, where the pictures 13' of the individual components are placed more densely packed than in the image according to Fig. 2, if the same optical magnification is used. It becomes then possible to increase the magnification of the optical lens system 5 and an image according to Fig. 4 can be obtained having larger individual pictures 13" of the individual components 3. With an increased enlargement an increased accuracy in the evaluation of the captured images is also achieved.

In order to obtain this, the region which is reproduced on the light sensitive surface 9 of the camera 7 is divided into sector shaped sub-regions by means of thin plates or lamellae 15, the surfaces of which are treated in order not to reflect light, for instance blackened and dulled. The sub-regions are placed next to each other, are open in a direction towards the video camera 7 and also to the opposite direction in order to let light through from a

component 3 retained by a tool 1. The openings are oblong in a transverse direction in relation to the row of the components 3 and only so wide, that the component 3 can well be placed therein in order to be reproduced on the light sensitive surface 9. Further, there are illumination devices for each sector shaped sub-region, which can be selectively activated to emit short light flashes, when a component 3 is located in front of or in its opening. The illumination devices can comprise either fixedly mounted lamps 17, which are placed above or behind the components, or fixedly mounted lamps 19, which are placed underneath the components 3, approximately in the openings of the sub-sectors. In any case the light emitted from the lamps must be shielded in a lateral direction, so that it does not reach more than one component, which is located in the sector shaped area associated with the lamps and shielded by the lamellae 15.

In the capture of an image according to Fig. 4 the following steps are hence performed. The lens system 5 and the camera 7 are assumed to be fixedly adjusted for a suitably selected, large magnification. The pickup head 2 is assumed to be equipped with eight pickup tools 1, which are numbered 1, 2, ..., 8 counted from the left as seen in Fig. 1. The sub-sectors formed by the partitioning lamellae 15 are numbered in the same manner from 1 to 8 as counted from the left. The pickup head 2 fetches during a movement to the right in the lateral direction, the x-direction, components 3, which are sucked to and are retained at the bottom surface of the pickup tool 1, and then moves to the left, as seen in Fig. 1.

When the pickup tools 1 with the retained components 3 get close to the lamellae 15, the light sensitive surface 9 of the video camera 7 is activated in order to receive an image, which is equivalent to opening the shutter in a conventional camera. According to a first preferred method the lamps 17 or 19 are activated during a very short time for sector No. 1 in order to emit a light flash, when the pickup tool No. 1 passes or is located in front of the opening to this sector with the retained component 3 in this opening, then the lamps for sector No. 2 are activated, when the pickup tool No. 2 passes or is located centrally in front of the opening of this sector, etc. According to a second preferred method the lights 17 or 19 are activated during a very short time for sector No. 8 in order to emit a light flash when the pickup tool No. 1 passes or is located centrally in front of the opening of this sector with the retained component 3 in this opening, the lights for sector No. 7 are then activated, when the pickup tool No. 2 passes or is placed centrally in front of the opening of this sector, etc. When either of these methods has been carried out for all the pickup tools Nos. 1 - 8, the achieved image from the light sensitive surface 9 is read, which is equivalent to the closure of the shutter in a conventional camera.

In the first method the shortest possible exposure time and the lowest risk for that scattered light shall reach the light sensitive surface 9 is obtained. In the second method longer times elapse between the captures of the overlapping images, which can be required for recharging a common electric circuit for driving the lamps 17 and 19 respectively for providing the strong light flashes. To reduce the amount of scattered light, the sensitivity of

the light sensitive surface 9 of the video camera 7 should also be adjusted to a rather low value and the individual light flashes from the lamps 17 and 19 respectively be made very light intensive.

In an evaluation of the superposed image, a reference must in some manner be used in order to determine the positions of the components 3 in relation to the pickup devices 1 or the pickup head 2.

According to a first embodiment, the successive images can be captured, when the pickup head and its parts continuously pass over the reproduction system. The elements in the light sensitive surface 9 of the camera 7 are then activated for very short time periods in order to capture images of the components 3, which is equivalent to opening the shutter of a conventional camera for a very short time, when a component 3 is present above an intended section. In this case there is no predetermined reference position, to which the fixedly adjusted reproduction system and its evaluation circuits for the captured image can relate the positions of the components 3. Therefor, a reference can be arranged in the captured image itself by attaching stiffly to the pickup head 2 reference projections 21, which extend in parallel to the longitudinal direction of the pickup tools 3 and which have a bottom surface, which is located approximately in the same plane as the bottom side of the components 3 or even can be allowed to be located at a distance behind this plane, as seen from the video camera 7. For a suitable location of the under surface of the projections 17, this is reproduced on the image captured for each component, as is shown at 23' in Fig. 3 and at 23" in Fig. 4. If the pickup tools 1 with their bottom surfaces only project a small distance from the bottom surface of the pickup head 2, reference marks attached to this under surface of the very pickup head can be used instead of reference projections.

According to a second embodiment each individual pickup tool 1 can be placed in a reference position suitably chosen for this pickup tool, during the capture of an image of the component 3 retained by the tool, and remain in this position, when the image of the component is captured. The reference positions are then different for the different pickup tools and the pickup head 2 must be moved to different reference positions for each pickup tool 1. This can be a rather time consuming process if a large number of pickup tools 1 are arranged.

In Fig. 5 a component assembly or pick-and-place machine is illustrated in a perspective view showing the general configuration of such a machine. A wagon 501 is movable along a horizontal bar 503, in the x-direction, to different locations, such as above magazine sites 505 intended to hold component feeders, which are movable in a horizontal direction, the y-direction, perpendicular to the guide bar 503 and above a circuit board 507 retained on a slide, also movable in the same direction as the magazine sites 505. The wagon 501 carries a pickup unit or head 2, from the lower side of which the vacuum pipettes 1 protrude downwards. The optical reproduction system including the video camera 7 can be located on one of the magazine sites 505.

CLAIMS

1. A method of reproducing components retained in a row, for an automatic evaluation of the positions of the components, **characterized in**

- that images of each individual component are captured and

- that the individual captured images are superposed for obtaining a composite image from which the positions of the components appear or can be deduced.

2. A method according to claim 1, **characterized in**

- that the images are captured by means of a fixed image capturing system having a fixed optical setting and

- that the components are moved between the capturing of an image of each individual component, so that the reproductions of the components in the composite image are located more closely together or are more densely packed than in a single image captured by the same image capturing system but simultaneously of several of the components.

3. A device for reproducing components retained in a row by retaining devices, for an automatic evaluation of the positions of the components, **characterized by**

- an image capturing device having a fixed optical setting

- - fixedly arranged in front of or underneath a path of the components during a movement of the retaining devices,

- - arranged to capture successive images of only one of the components at each time during the movement thereof past the image capturing device and

- - comprising means for superposing the captured images for forming a composite image.

4. A device according to claim 3, **characterized in** that the image capturing device comprises shielded illumination devices for illumination of only one component at a time.

5. A device according to claim 4, **characterized in** that the illumination devices comprise light sources which can be activated during short times and fixedly arranged lamellae or shielding elements.

6. A device according to claim 5, **characterized in** that the lamellae or shielding elements comprise shielding walls positioned for forming sector shaped spaces, located next to each other having openings facing the locations, where the components are moved, and facing the location of a reproduction system being part of the image capturing device.

7. A device for reproducing components retained in a row by retaining devices, for an automatic evaluation of the positions of the components, **characterized by**

- an image capturing device arranged in front of or underneath the components, for capturing successive images of the components, each image of which being captured of only one component, when the retaining device, which retains this component, is in a reference position, so that the images show different components,

- the image capturing device being arranged to superpose the captured images on each other to form a composite image, so that the reproductions of the components in the

composite image are located more closely to each other or are more densely packed than in one single image captured by means of the same image capturing system, but simultaneously of several of the components.

8. A component assembly machine comprising

- a pickup head, which is movable between a location for picking-up components and a placement location,

- at least two retaining devices on the pickup head for gripping, retaining and releasing components and

- a system for an automatic evaluation of the positions of the components, when these are retained by the retaining devices,

characterized by

- an image capturing device having a fixed optical setting

- - fixedly arranged in front of or underneath the path of the components during a movement of the retaining devices,

- - arranged to capture successive images of only one of the components at a time during a linear movement thereof past the image capturing device, when the pickup head moves from a picking-up location to a placement location, and

- - comprising means for superposing the captured images for forming a composite image.

9. A component assembly machine comprising retaining devices for retaining components and further comprising a system for an automatic evaluation of the positions of the components,

characterized in

- that each of the retaining devices can adopt a reference position,

- one single fixedly arranged image capturing device being arranged in front of or underneath each of the components, when their respective retaining devices are in their reference positions,

- which image capturing device is arranged to capture images of one of the components at a time, when the retaining device, which retains the component is in its reference position, and to superpose the images captured in this manner for obtaining a composite image.

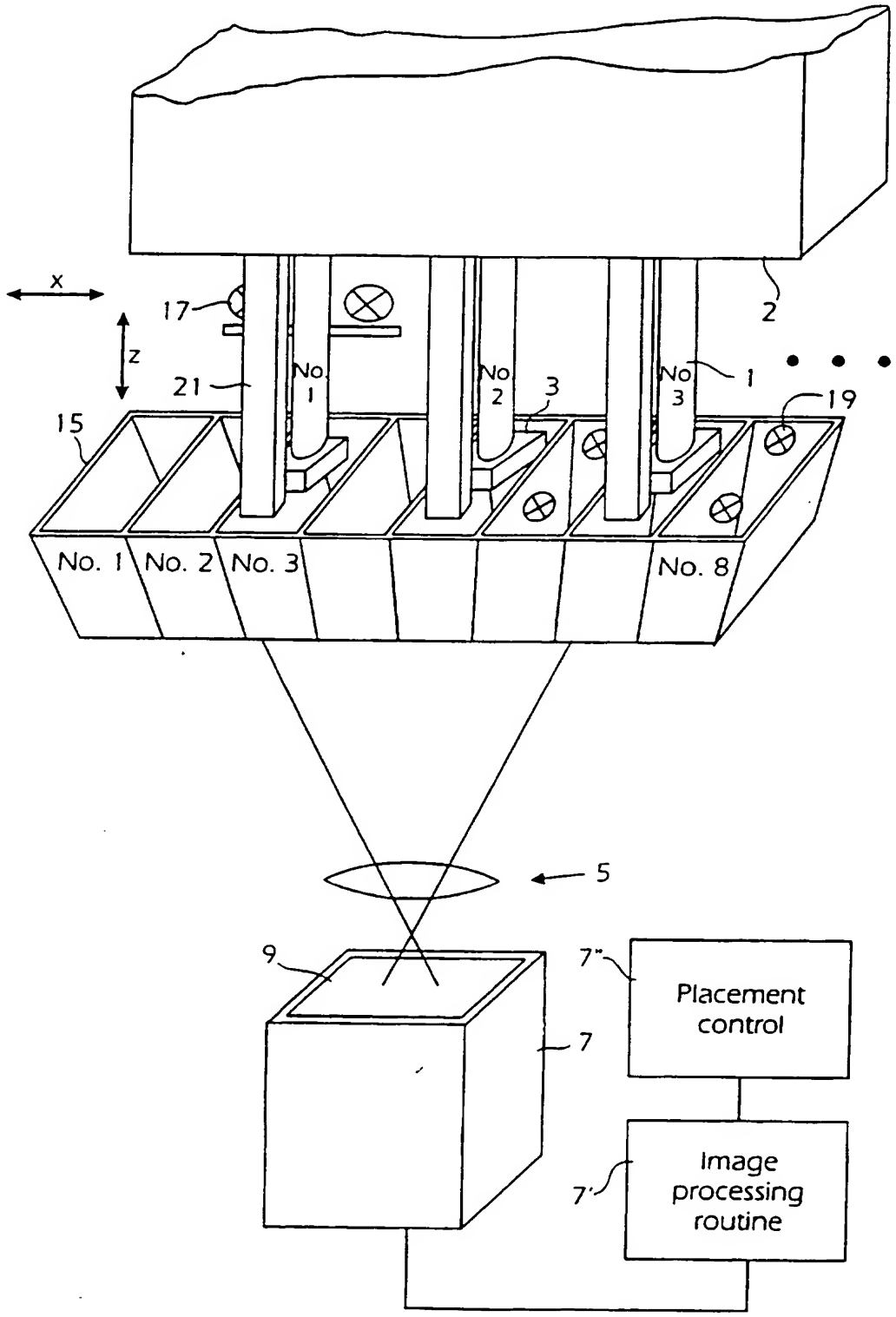


Fig. 2

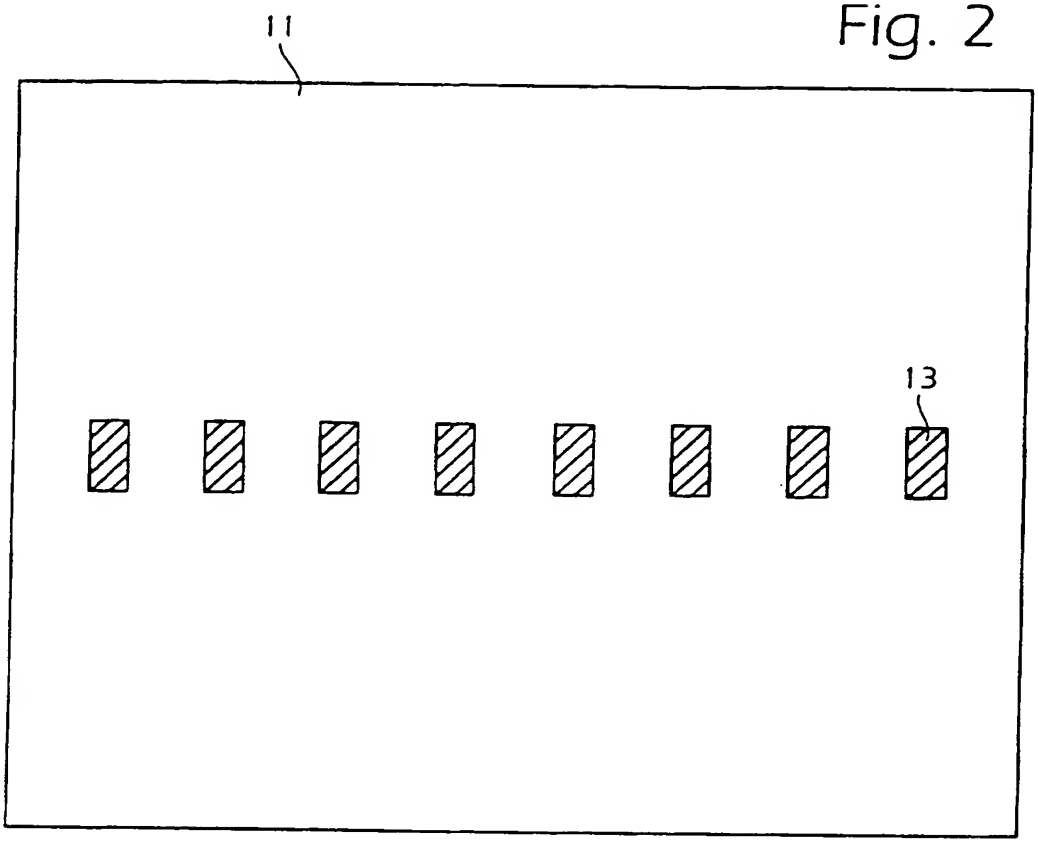


Fig. 3

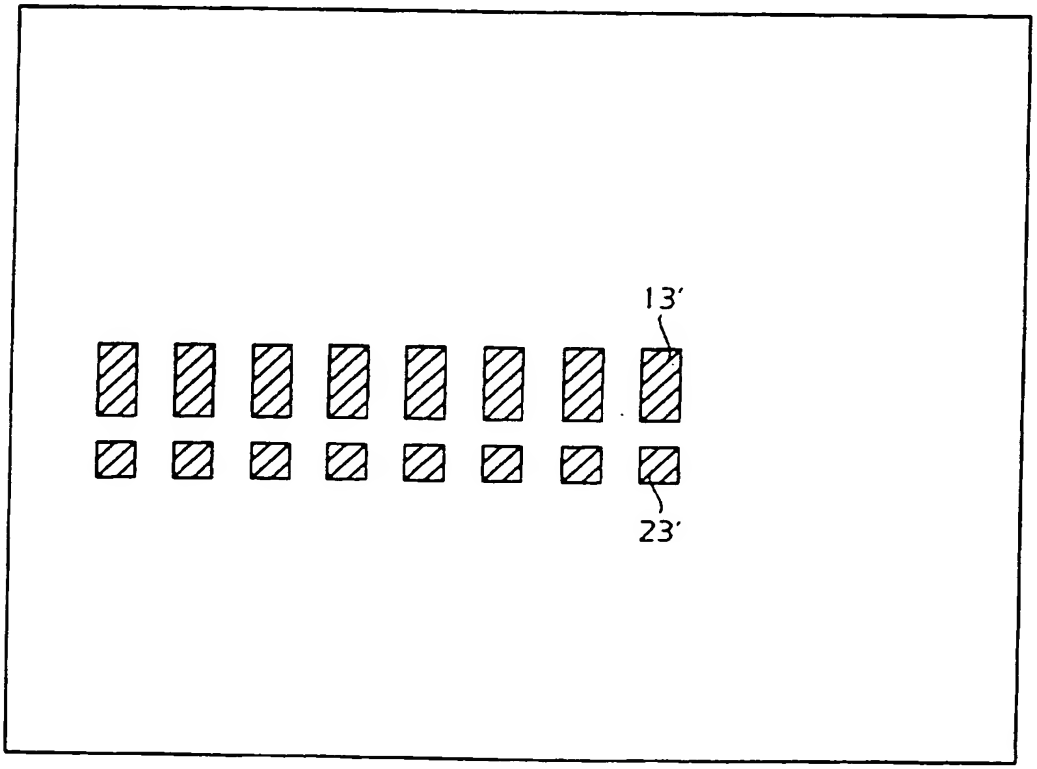
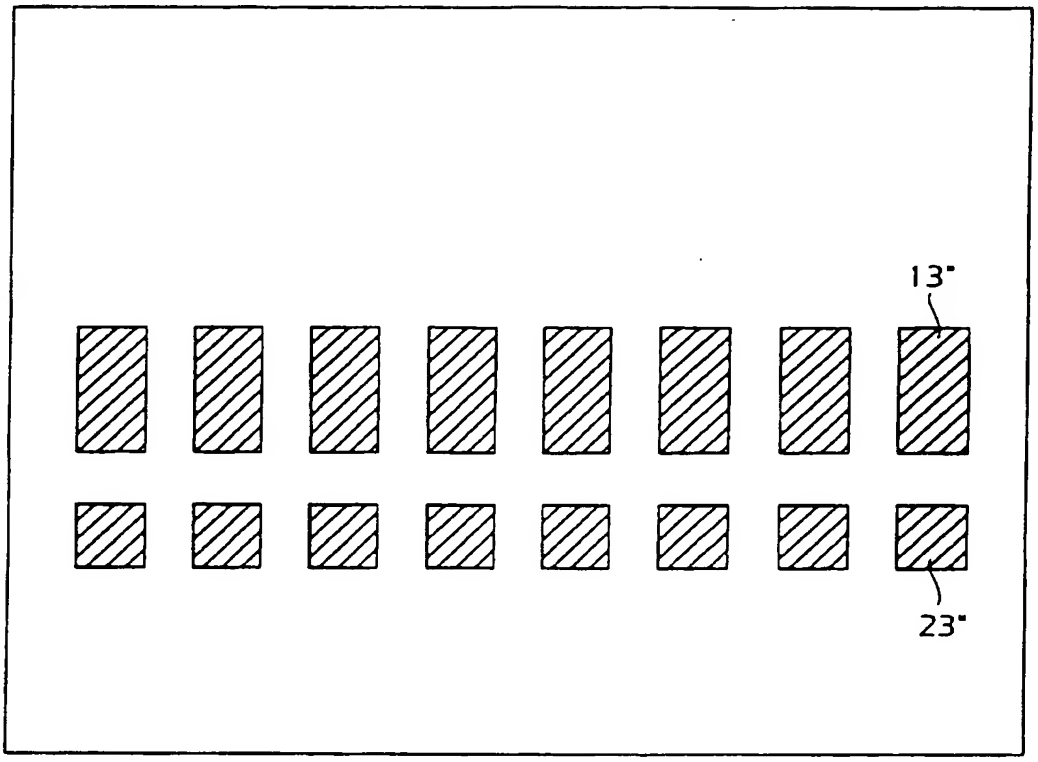


Fig. 4



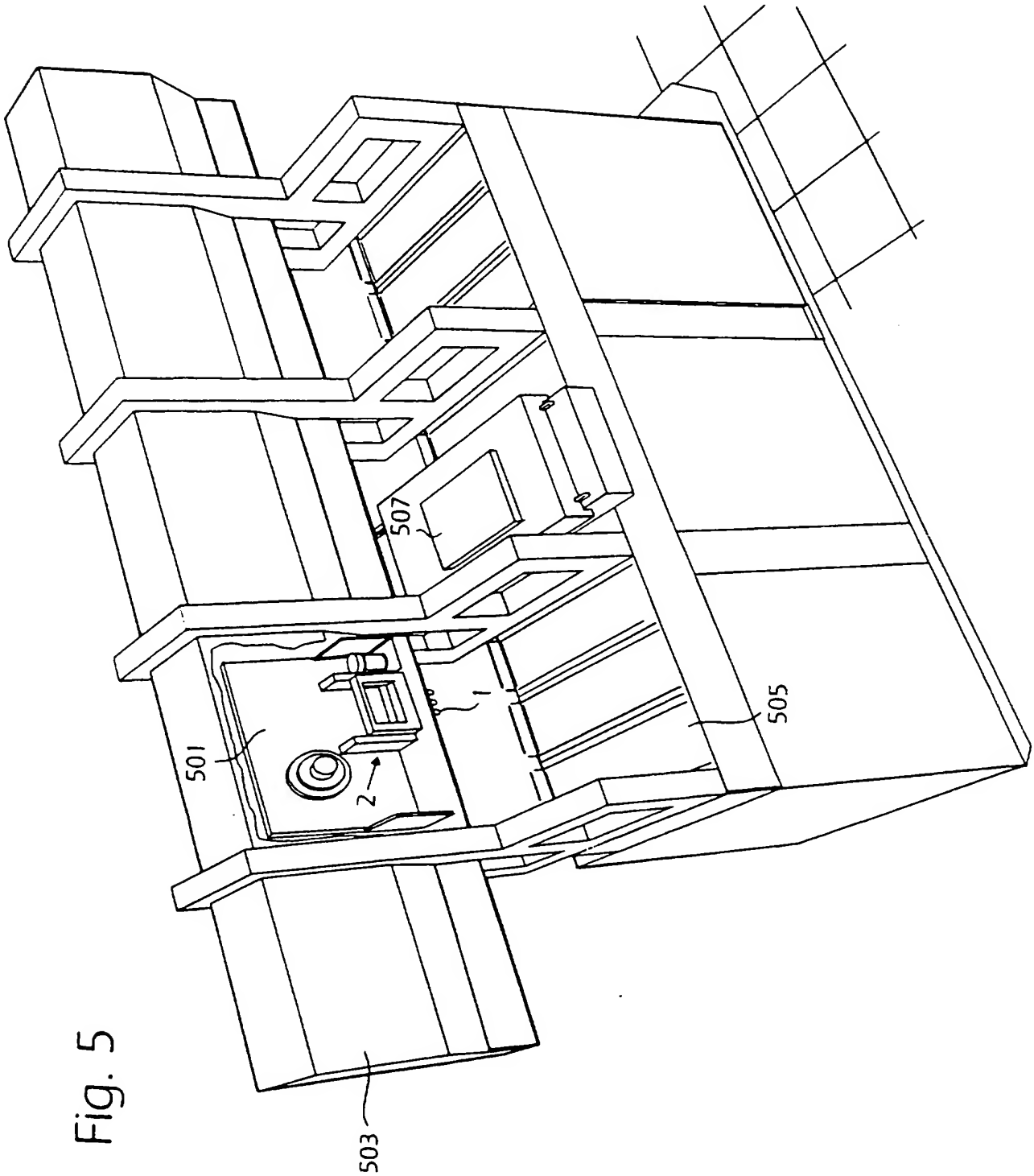


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/01176

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H05K 13/08, G01C 11/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H05K, B25J, G02B, G01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Focus Uppslagsbok, "Del 10 Tekniken", 1983, Esselte Focus Uppslagsböcker AB, (Stockholm), page 239; page 282	1,8,9
A		2-7
	--	
A	EP 0330294 A2 (MOLEX INCORPORATED), 30 August 1989 (30.08.89), abstract	1-9
	--	
A	EP 0374848 A2 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 27 June 1990 (27.06.90)	1-9
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/01176

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0471272 A1 (TDK CORPORATION), 19 February 1992 (19.02.92), abstract ---	1-9
A	EP 0577080 A1 (EZEL INC.), 5 January 1994 (05.01.94), abstract ---	1-9
A	EP 0596533 A1 (YAMAHA HATSUDOKI KABUSHIKI KAISHA), 11 May 1994 (11.05.94), abstract --- --------	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

05/02/96

International application No.
PCT/SE 95/01176

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A2- 0330294	30/08/89	JP-A- 1240000	25/09/89
		JP-C- 1670598	12/06/92
		JP-B- 3030319	26/04/91
		US-A- 4810154	07/03/89
EP-A2- 0374848	27/06/90	JP-A- 2165699	26/06/90
		US-A- 5068588	26/11/91
EP-A1- 0471272	19/02/92	JP-A- 4094600	26/03/92
EP-A1- 0577080	05/01/94	NONE	
EP-A1- 0596533	11/05/94	NONE	